Amendments to the Specification:

Please replace paragraph 0024 with the following amended paragraph:

[0024] Referring now to FIG. 2A, the computer model of the lower jaw 100 includes a plurality of teeth 102, for example. At least some of these teeth may be moved from an initial tooth arrangement to a final tooth arrangement. As a frame of reference describing how a tooth may be moved, an arbitrary centerline (CL) may be drawn through the tooth 102. With reference to this centerline (CL), each tooth may be moved in orthogonal directions represented by axes 104, 106, and 108 (where 104 is the centerline). The centerline may be rotated about the axis 108 (root angulation) and the axis 104 (torque) as indicated by arrows 110 and 112, respectively. Additionally, the tooth may be rotated about the centerline ~~as represented by an arrow 114~~. Thus, all possible free-form motions of the tooth can be performed.

Please replace paragraph 0029 with the following amended paragraph:

[0029] The polymeric appliance 111 of FIG. 2C may be formed from a thin sheet of a suitable elastomeric polymer, such as Tru-Tain 0.03 in, thermal forming dental material, available from Tru-Tain Plastics, Rochester, Minnesota. Usually, no wires or other means will be provided for holding the appliance in place over the teeth. In some cases, however, it will be desirable or necessary to provide individual anchors on teeth with corresponding receptacles or apertures in the ~~appliance 100~~ <u>appliance 111</u> so that the appliance can apply an upward force on the tooth that would not be possible in the absence of such an anchor.

Please replace paragraph 0031 with the following amended paragraph:

[0031] As a first step, an initial digital data set representing an initial tooth arrangement is obtained (step 202). The initial data set may be obtained in a variety of ways. For example, the patient's teeth may be scanned or imaged using X-rays, three dimensional X-rays, computer-aided tomographic images or data sets, or magnetic resonance images, among others. The teeth data may be generated by a destructive scanner, as described in the incorporated-by-reference U.S. Application Serial No. 09/169,034, filed October 8, 1998<u>, now U.S. Patent No. 6,471,511</u>.

The initial data set is then manipulated using a computer having a suitable graphical user interface (GUI) and software appropriate for viewing and modifying the images, and a final digital data set corresponding to a desired final tooth arrangement is produced (204). More specific aspects of this process will be described in detail below. Individual tooth and other components may be segmented or isolated in the model to permit their individual repositioning or removal from the digital model.

Please replace paragraph 0032 with the following amended paragraph:

[0032] After segmenting or isolating the components, the teeth are moved based on rules and algorithms programmed into the computer. In this step, each stage of tooth movement is determined by an attraction model between selected points on adjacent teeth. This step is iterated until an acceptable result is achieved and intermediate digital data sets corresponding to teeth arrangements are generated (step 206). In one embodiment, the system stops the movement when the relative positions of the teeth satisfy a predetermined target.

Please replace paragraph 0035 with the following amended paragraph:

[0035] FIG. 4 shows an embodiment for paratherm forming an object such as a group of teeth on a dental arch. During manufacturing, a sheet of material such as plastic is placed over a physical model of an object to be produced. In one embodiment, the physical model is produced by a stereo-lithography apparatus (SLA). The sheet is heated in a thermo-former, using rapid moving optics to direct the energy beam of a heat source such as a laser onto the sheet prior to and/or during the application of pressure onto the sheet. Turning now to FIG. 4, a heat source 300 such as a laser ~~300~~ generates a beam of energy that is projected through a beam expander 302 and a recollimating lens 303. The beam is then reflected by a mirror 304. The reflected beam hits on a sheet 312 that is placed proximate to a forming die 310 of a physical model of an object to be produced. In one embodiment, the sheet 312 is positioned between the beam and the die 310. An infrared (thermal) imaging camera 316, aimed at the plastic sheet 312, provides feedback data on heating performance. The thermal camera 316 provides a real-time feedback loop to a control system (not shown) by comparing the actual thermal profile with the CAM

profile and making adjustments to laser parameters instantly or for process tuning and SPC. The camera output is also useful for process development.

Please replace paragraph 0037 with the following amended paragraph:

[0037] One or more ports 328~~330~~ and 330 on the plenum allow flow-through of chilled pressurized gas that can accelerate the setting of the formed sheet. Additionally, this flow-through feature can be used for transporting hot gas across the sheet 312 during heating in order to retard convective heat dissipation from the sheet 312, thus enlarging the time 'window' for laser writing. The system uses separate volumes of heated and cooled gasses (and valves) that are not shown in FIG. 4. The system provides a very rapid sheet heating technique that should be complemented with fast forming and fast cooling for a short forming cycle.

Please replace paragraph 0041 with the following amended paragraph:

[0041] Rapid laser scanning allows ~~the~~ profiling of a heat pattern because forming can occur before heat is dissipated. The forming pressure plenum is integrated with the heating source 300 so that the sequence of heating and forming can be very rapid or overlapping. This configuration allows an opportunity for forming before the plastic sheet cools to temperatures below the glass-transition point at any area of the sheet. The large collimated laser beam allows the light energy profile to remain constant at different distances that the sheet may encounter during forming, so scanning while forming is viable on the surfaces that are most oblique to the laser beam.

Please replace paragraph 0042 with the following amended paragraph:

[0042] Expansion and recollimation of the laser beam is desirable for heating a large area at any moment. The intrinsic Gaussian radiance profile of the laser is preserved and spread with these optics, delivering energy rapidly with control over hot spots. This Gaussian delivery is optically tunable, so it provides control over the homogeneity of energy, much like an airbrush provides control over the scale and 'softness' of an artists brushstrokes. This technique enhances the versatility of 'writing' a thermal image to the plastic sheet by enabling broad warm areas to be filled and thinner hot areas to be defined in rapid succession. Beam sizing is controlled by

servo or manual adjustment of the recollimating lens using the axis of the divergent beam. This beam sizing could be computer controlled on-the-fly or done manually in process development, either method with the goal of keeping the heat of all areas of the plastic sheet within safe range of glass-transition temperatures. Dispersion of focused heat over time would be important to consider when tuning the power and diameter of the laser beam. Alternatively, recollimation can be accomplished with a concave mirror ~~314~~ 304 wherein beam sizing would be effected by adjustment of the beam expander 302 along the optical axis.

Please replace paragraph 0050 with the following amended paragraph:

[0050] During processing, synchronization lines 412 are projected from the synchronization point 410 to target point 408. The synchronization point 410 can be pre-established in position on the source spline or template 404. The target point 408 that correlates with the synchronization point 410 should be positioned on the target spline 406. In one embodiment, an orthogonal or plan view of FIG. ~~4A~~ 5A can be used to generate orientations for synchronization lines 412 defining a tool path 414 and that appear as surface normals to the target spline 406. The direction for each projection is from the source spline (404) to the target spline (406) and represents the equivalent of surface normals to the smoothed target spline 452 (FIG. 6) (mathematically smoothed 3D spline). The projection is done such that the synchronization lines 412 are substantially orthogonal to the mathematically smooth spline 452 (FIG. 6). The length of the surface normals is adjustable. Long normals tend to resemble the average more than short normals since angular changes from specific target splines change more radically with angular changes for short normals. Short normals tend to provide high resolution at the expense of more data having to flow through the CAM system. Alternatively, long normals would provide faster motion at the expense of precision and resolution because the angular changes have to be accurately controlled.

Please replace paragraph 0053 with the following amended paragraph:

[0053] FIG. 5B is another view of FIG. 5A. FIG. 5B shows the object 402 resting on a support 430. FIG. 5B also shows a smooth path 432 for the motion of the system~~, of the laser 404~~. In

the exemplary embodiment of FIG. 5B, trim vectors 420 are approximately forty degrees relative to object surface normals. The object 402 bears a generalized relationship to the surface normals so that the angle is constant in this example. The surface normals of FIG. 5B follow a predetermined formula that is based on an idealized model of the object 402.

Please replace paragraph 0054 with the following amended paragraph:

[0054] The motion system of Figs. 5A and 5B follows the tool path and has a motion that is generally smooth and constantly leading. As the motion system follows the source spline 404 or an equivalent of the source spline 404, its motion is smooth. Further, any vectors that relate to a position at any moment in time of the motion system at 404 as it moves forward also relates to a forward motion along the target spline (408). Thus, a correlated move generally exists in the forward direction between the motion system and the target object itself.

Please replace paragraph 0056 with the following amended paragraph:

[0056] In FIG. 6, synchronization lines ~~412~~ that descend from the top spline to the bottom spline are representative of the direction (vector) of the trim beam or tool axis at different positions around the path. The CAM interpolates the tool path between synchronization lines. Due to the interpolation, the resulting motion of the source device (laser motion devices) is smooth and progressive without sharp turns or reversals. In embodiments where the source device is a laser or projected beam device where effective focus occurs with substantial focal depth, the source device does not need to track the target along the axis of the trim beam, even though the target spline articulates in this beam-axis direction.

Please replace paragraph 0059 with the following amended paragraph:

[0059] The smoothed spline generated using the process 450 is then used to cut or trim the object. The source spline data is loaded as part of a template of a computer aided manufacturing (CAM) system. This makes the CAM system capable of accepting specific target spline data as a complement that fulfills most data requirements needed to generate a specific tool path. The template can include the data requirements. Further, ~~and~~ part orientation information for

fixturing the workpiece ~~must~~can be included in the template to assure the correlation of geometry between the device tool path and the workpiece during operation. Part orientation is established with a three-axis Cartesian datum that is common between the ideal model and all specific models. Additional common data incorporated in the template may include other process parameters such as motion velocities, effecter power (flow rate, flow velocity, focus, etc.), temperature, and pulse rate. The template can also include algorithms for adjustment of process parameters that are triggered by special geometric conditions of the target spline or by special notation attached to the target spline file.